Arch. Ryb. Pol.	Archives of Polish Fisheries	Vol. 7	Fasc. 1	5 - 13	1999

USING SCLERITE NUMBER DISTRIBUTION IN MARGINAL GROWTH OF SCALE FOR AGEING SEA TROUT SPAWNERS (*Salmo trutta* morpha *trutta* L.) FROM THE VISTULA RIVER

Paweł Buras

The Stanisław Sakowicz Inland Fisheries Institute in Olsztyn

ABSTRACT. Distribution of sclerite numbers in marginal scale growth of A.1+, A.2+ pattern in sea trout spawners was analysed. Two distinct peaks of sclerite numbers were obtained. Two phases of growth were distinguished: small marginal growth and big marginal growth, used as a basis of age determination in sea trout spawners. Probability of error in trout ageing was calculated for the area where the distribution curves overlapped.

Key words: TROUT, CIRCULI, MARGINAL GROWTH, AGE.

INTRODUCTION

Analysis of fish age using scales is based on the distribution analysis of annual rings scale growth. Marginal growth measurement is used to distinguish the new circuli from the last-year ones (Joris 1956, Backiel 1962, Sych 1967a, Sych 1967b). Time of annual circuli formation estimated with this method for salmon, trout, and cyprinid scales was highly variable in random samples. Marginal growth distribution showed two peaks related to this variability; based on this the marginal growth was divided into two groups: this-year small, and last-year big growth. Using this system, the fish were included in two different age groups (Backiel 1962, Sych 1967a).

In the previous study (Sych 1967a) the material was collected during trout circuli formation, from June to August. New circuli differed considerably from the last-year ones. In the present study advantage was taken of the material collected from July to October from sea trout spawners in the Vistula River. In view of this the new circuli in late migrating fish might be similar to the previous ones.

Marginal scale growth is related to fish body growth d_k (Backiel 1962, Sych 1967a), according to the formula:

$$d_k = L - \frac{L}{S} \cdot s_k$$

where:

L – fish length in mm,

S - scale radius

s_k – section of the scale radius from the centre to the last annual circulus.

In the present study marginal growth of scales was expressed as the number of sclerites behind the last annual ring. Number of sclerites is a suitable measure for scale discriminate analyses (Reddin 1981, Borzęcka et al. 1990). Moreover, highly significant correlation was found between the number of sclerites and scale size (Tuszyńska, Sych 1983). Thus, taking into consideration the new approach, two issues were analysed:

– whether the distribution analysis of marginal growth may be used for ageing sea trout spawners,
– whether the number of sclerites is a reliable measure of marginal scale growth.

MATERIAL AND METHODS

Scales of trouts entering the Vistula and harvested from July to October 1984-1986 in Świbno were used in the study. The fish were kept in tanks, until artificial spawning in November and December. The scales were sampled at the same time. Scale prints were used for ageing and counting of the sclerites (Sych 1964). Only marine growth was taken into consideration i.e. in A.1+, A.2+ etc. Notation letter „A" is related to the smolt stage.

Scales from the lower Vistula trouts were used for standard distribution curves of annual growth. Then scales from a year-older fish were sampled, and sclerites were counted in the growth preceding the last annual ring. For example: for A.1+ fish from Świbno, scale growth in the second marine year of trout entering the Vistula at the age A.2+ was used as a standard. Standard samples of trout at the age A.2+ were obtained in 1984-1986, and A.3+ in a longer period.

According to earlier definitions (Sych 1967a, 1967b, 1971), it was assumed that:

– marginal growth involves area behind the last annual ring,
– annual ring is defined as borderline between annual growths of scale, and not as density of sclerites, nor entire annual growth,
– annual ring defined in such a way becomes visible after the new annual growth has started, thus scale pattern is always „A.B+", and not A.B." (no marginal growth +),

– notation „A.B+" (where B – number of rings in marine zone of the scale) is not identical throughout the fish age, it is related to the age of an individual, or - alternately - to the scale pattern,
– transformation of scale pattern into fish age, taking into consideration number of circuli (B) and marginal growth magnitude (+), is performed according to the rule:

If	Then		
Marginal growth (+)	Scale pattern		fish age
Small	A.B+	→	A.B+
Big	A.B+	→	A.B+1+

Magnitude of marginal growth was calculated from the number of sclerites between the last annual ring and the scale edge. Only oral side sclerites were counted. The scales were examined at 42x magnification using Lean Terminal analyser.

RESULTS AND DISCUSSION

Frequency distribution of sclerite numbers in marginal growth in trouts having scale pattern A.1+ showed considerable variation with two distinct peaks (Fig. 1).

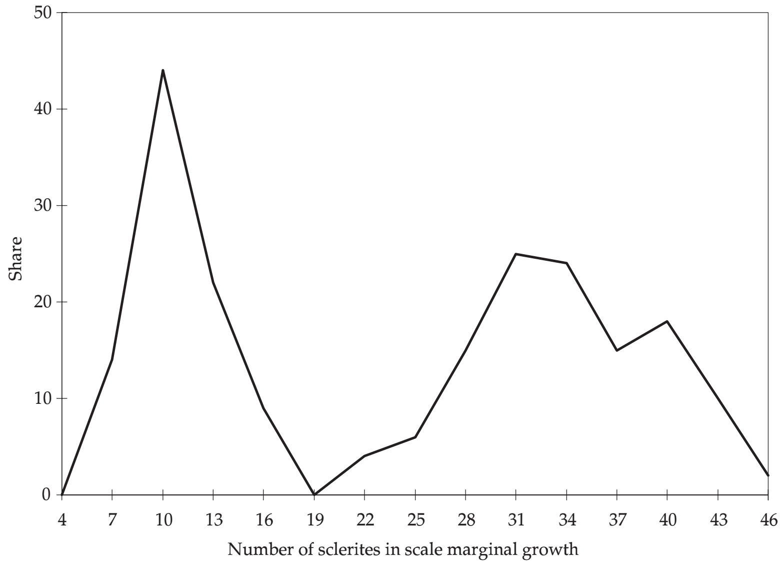

Fig. 1. Empirical distribution of sclerite number in scale marginal growth (N = 208, M = 24.1, S.D. = 12.2) in trouts of scale pattern A.1+ harvested in 1984-1986 in Świbno.

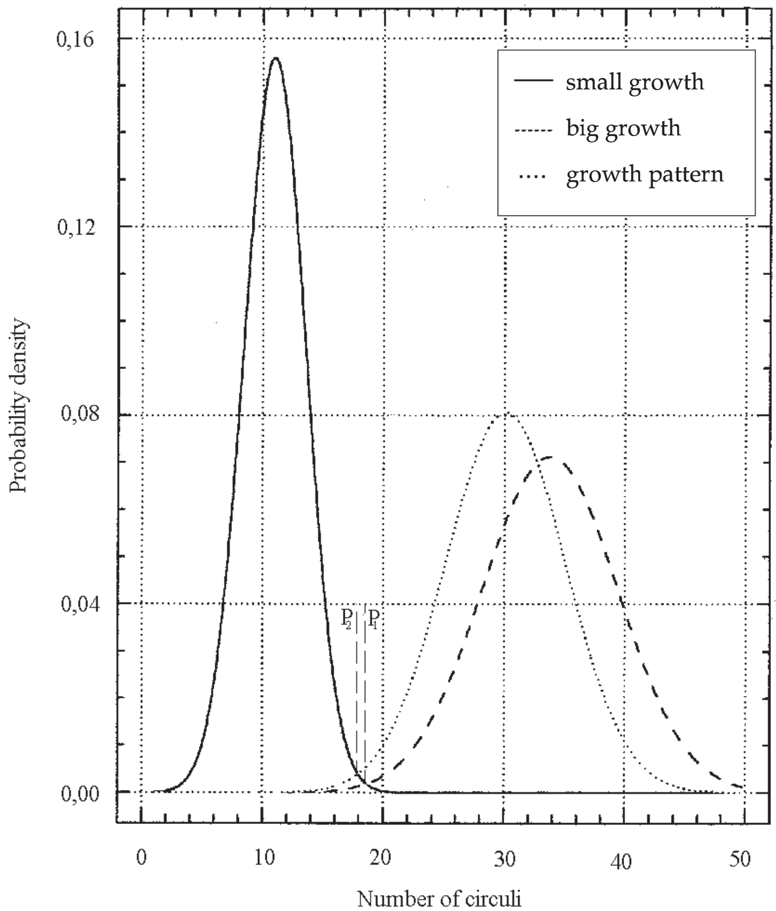

Fig. 2. Hypothetical distribution of sclerite number in „small" growth (N = 89, M = 11, S.D. = 2.56), and in „big" growth (N = 119, M = 33, S.D. = 5.6) in trouts of scale pattern A.1+, and hypothetical standard distribution of sclerite number in the entire annual ring in trout of A.2+ age (N = 137, M = 30.1, S.D. = 4.95) harvested in 1984-1986.

These peaks led to the division of growth into „small growth" – left peak, and „big growth" – right peak. Mean and standard deviation were calculated for each peak, and normal distribution curve was developed (Fig. 2). Division line P_1 between „small" and „big" growth is determined by the 19-th sclerite. After superimposition of the standard distribution of yearly growth of trouts at the age A.2+, division line (P_2) moved towards „small" growth, to the 18-th sclerite (Fig. 2). Parameters of distribution of sclerite number in „small", and „big" growth, parameters of standard distribution, and divisions P_1 and P_2 are shown in Table 1 for each year of the study. The shape of distribution curve of sclerite numbers in marginal growth of trout scales of A.1+ pattern was identical to that of body growth d_k calculated from marginal scale growth (Zawisza 1961, Backiel 1962, Sych 1967a).

TABLE 1

Theoretical distribution of sclerites and small and big growth of trout scale A.1+, and in the entire annual growth of trout aged A.2+ in each year

Year	Small growth (this year)			Big growth (last year)			Standard growth			Divisions	Divisions
	N	M	S.D.	N	M	S.D.	N	M	S.D.	P	P
1984	19	9.9	1.8	16	33.7	6.7	23	29.2	5.9	16	15
1985	39	10.6	2.7	93	33.9	5.6	71	30.8	4.7	18	18
1986	31	12.2	2.4	10	33.8	3.8	43	29.3	4.7	21	18

Distribution of sclerite numbers of marginal growth in trouts with A.2+ scale pattern showed only one peak, and the entire range from 4 to 20 sclerites (Fig. 3). Previous studies revealed two-peak distribution of marginal growth in trout of A.2+ scales (Sych 1967a). Thus, it was assumed that empirical distribution of sclerite number

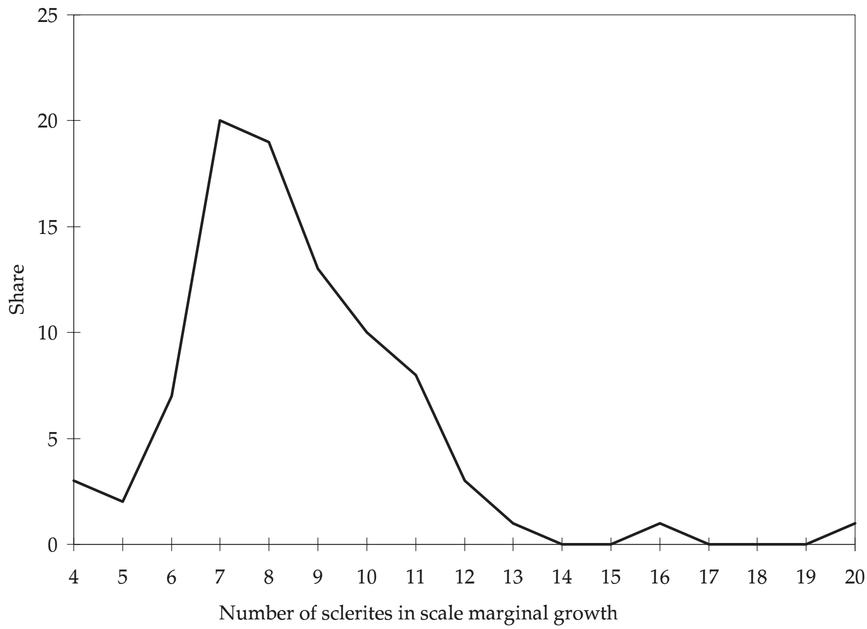

Fig. 3. Empirical distribution of sclerite number in scale marginal growth (N = 88, M = 8.47, S.D. = 2.39) in trout of A.2+ scale pattern harvested in 1984-1986 in Świbno.

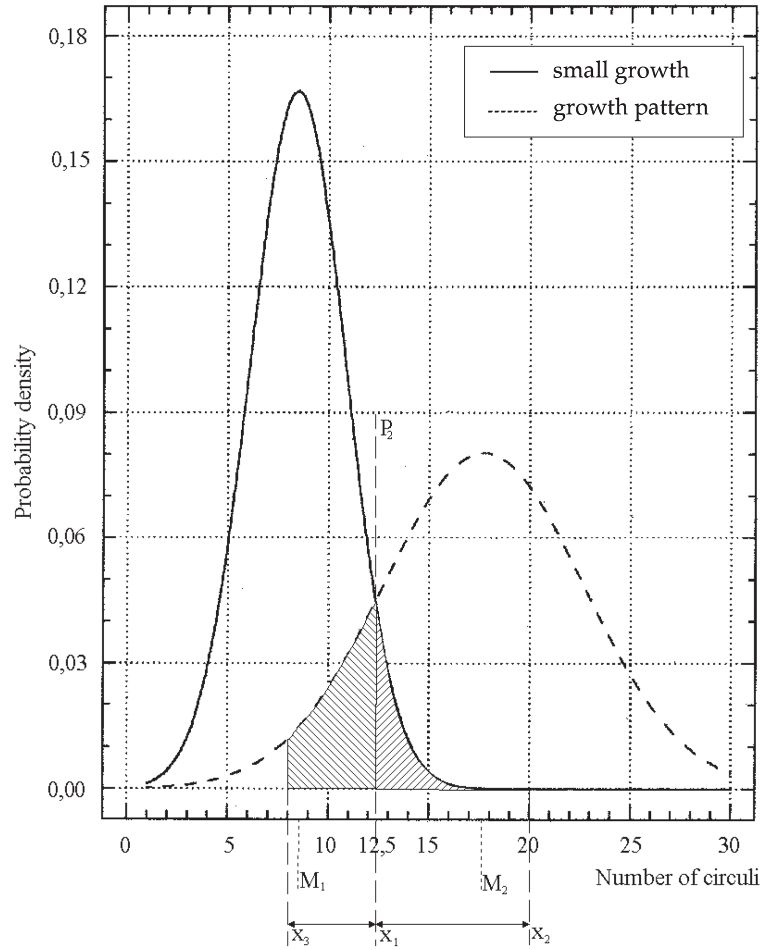

Fig. 4. Hypothetical distribution of sclerite number (values from Fig. 3) in trout of A.2+ scale pattern in 1984-1986, and standard hypothetical distribution of sclerite number in the entire annual ring (N = 32, M = 17.7, S.D. = 4.97) in trout at the age A.3+ harvested over many years.

shown in Fig. 3 was related to „small” marginal growth. Normal distribution curve was developed and compared with normal distribution of standard sclerite numbers of trouts aged A.3+. Hypothetical distribution curves shown in Fig. 4 overlap, and P_2 division runs between 12 and 13 sclerite.

Dashed area was calculated according to Łomnicki (1995):

$$z = \frac{x - M}{\sigma}$$

where:

z – area under the normal distribution curve

x – distribution function value

M – mean

σ - standard deviation

Parameters used in calculation are shown under Fig. 4:

$x_1 = P_2$ – hypothetical division into „small", and „big" marginal scale growth - intersection point of normal curves

x_2 – maximum sclerite number found in „small" marginal growth

x_3 – minimum sclerite number found in „big" marginal growth (in the standard sample)

M_1 – mean sclerite number in „small" growth distribution

M_2 - mean sclerite number in „big" growth distribution (in the standard sample)

Thus, the following values were obtained for „small" growth:

area z_1 between $x_1 = 12.5$ to $M_2 = 8.47$ was equal to 0.4535

area z_2 between $x_2 = 20.0$ to $M_2 = 8.47$ was equal to 0.5000

and the difference $z_2 - z_1$ was equal to $0.0465 \approx 0.05$

For „big" growth:

area z_1 between $x_1 = 12.5$ to $M_2 = 17.7$ was equal to 0.3531

area z_2 between $x_3 = 8.0$ to $M_2 = 17.7$ was equal to 0.4744

and the difference $z_2 - z_1$ was equal to $0.1213 \approx 0.12$

Calculated differences are equal to the probability of error expected for ageing trouts of A.2+ scale pattern due to overlapping of the two distribution curves. This probability is equal to 5% for fish showing small marginal growth, and to 12% for fish with big growth.

Using division $P_2 = 12.5$ for the empirical data (Fig. 3), the following results were obtained: sample of N = 88 individuals consisted of 85 fish at the age A.2+, and 3 fish A.3+. The last group was represented by extended and dispersed sections of curve shown in Fig. 3, of $x \geq 13$. Due to very little number of fish (3 individuals) 12% probability of error is not applicable. The results seem to fit the reality since individuals aged A.3+ and older were rarely observed in the Vistula sea trout (Borzęcka 1997). Division $P_2 = 12.5$ for fish of A.2+ scales may be verified comparing with $P_1 = 19$ division for A.1+ scaled fish. P_2 value has to decrease with an increase of ring numbers in the same way as annual body and scale growth decreases with fish age (Figs. 2, 4, also Sych 1967a).

Hypothetical error area shown in Fig. 4 probably does not depend on any of the following parameters: fish growth, scale growth, or sclerite number. Further development of the method could involve in this area the structure of scales in „marginal zone", using the new approach (Nabiałek 1994).

CONCLUSIONS

1. Distribution analysis of marginal growth is useful in ageing trout spawners. Trout individuals with or without newly formed annual ring may be distinguished. Age of the first group is related to the number of annual rings, and in the second group – one year must be added to this number.
2. Number of sclerites is not a reliable measure of marginal scale growth. Distribution of sclerite number reflects distribution of body growth d_k.
3. Sclerite number distribution is identical in successive trout cohorts, but contribution of older fish decreases. Division value decreases with an increase of the number of scale annual rings.
4. It is possible to estimate error probability for the evaluation of trout age from the overlapping area of marginal growth distribution curves. The probability of error increases with the age of fish.

REFERENCES

Backiel T. 1962 Determination of time of annulus formation on fish scales Acta Hydrobiol. 4, 3 4: 393 411.

Borzęcka I. 1997 Charakterystyka troci wiślanej *Salmo trutta* morpha *trutta* (L.) poszukiwanie kryteriów restytucyjnych Rozprawa doktorska w IRŚ (maszynopis).

Borzęcka I., Ikonen E., Torvi I. 1990 Attempts of using the discriminant function based on scale structure of baltic salmon to distinguish between the wild and hatchery reared smolts ICES, M: 21 Ana.Cat.

Jöris L. S. 1956 Structure and growth of scales of yellow perch of Green Bay Trans. Am. Fish. Soc., vol. 86.

Łomnicki A. 1995 Wprowadzenie do statystyki dla przyrodników Wydawnictwo Naukowe PWN Warszawa.

Nabiałek J. 1994 Klasyfikacja pierścieni na łuskach ryb o znanym wieku rzeczywistym Arch. Ryb. Pol. 2, 1: 3 58.

Reddin D. G. 1981 Stock identyfication ICES C.M. 1981 Appendix 4.

Sych R. 1964 Metoda odciskania łusek na tworzywie sztucznym Rocz. Nauk Rol. 84 B, 2: 347 361.

Sych R. 1967(a) Oznaczenie wieku troci (*Salmo trutta* L.) w okresie formowania się pierścieni rocznych Rocz. Nauk Rol. 90 H, 2: 305 325.

Sych R. 1967(b) Interpretation of the scale of Vistula sea trout (*Salmo trutta* L.) Acta Hydrobiol. 9, 3 4: 23-1-280.

Sych R. 1971 Elementy teorii oznaczania wieku ryb według łusek. Problem wiarygodności Rocz. Nauk Rol. 93 H, 1: 1 73. English version published in EIFAC Tech. Pap., no. 13, FAO, Rome 1971.

Tuszyńska L., Sych R. 1983 Attempts of using the scale characteristics for separation of some Baltic salmon and trout stocks A part of the pilot studies to the Baltic Salmon Working Group 28th Meeting, I-CES, Ana.Cat. Fish Cttee, C.M. 1983 M29, App. 6: 43 79.

Zawisza J. 1961 Wzrost ryb w jeziorach okolic Węgorzewa. Próba ustalenia niektórych prawidłowości Rocz. Nauk Rol. 77 B, 2: 681 748.

STRESZCZENIE

WYKORZYSTANIE ROZKŁADU LICZBY SKLERYTÓW W PRZYROŚCIE KRAWĘDZIOWYM ŁUSEK DO OKREŚLANIA WIEKU TARLAKÓW TROCI (*Salmo trutta* morpha *trutta* L.) W UJŚCIU WISŁY

Oznaczanie wieku ryb z łusek wiąże się z analizowaniem rozkładu wielkości przyrostów krawędziowych na łusce. W badaniach wykorzystano materiał łuskowy gromadzony zimą w latach 1984 1986 z tarlaków troci wstępującej do Wisły w okresie od lipca do października, łowionej i przetrzymywanej potem do sztucznego tarła w Świbnie. W tej pracy badano rozkład liczby sklerytów w przyroście krawędziowym łuski w dwóch grupach troci: A.1+ i A.2+. Do wykreślenia wzorcowego rozkładu całorocznych przyrostów użyto materiału łuskowego z troci starszych o rok i łowionych w dolnej Wiśle. Skleryty na łuskach tych ryb zliczano w przyroście poprzedzającym ostatni pierścień roczny. Dla troci o obrazie łuski A.1+ i A.2+ ze Świbna, wzorcami były odpowiednio rozkłady liczby sklerytów w drugim roku morskim u troci w wieku A.2+ i w trzecim roku morskim u troci w wieku A.3+.

Empiryczny rozkład liczby sklerytów w przyroście krawędziowym na łusce u troci z grupy A.1+ przyjął kształt dwuwierzchołkowy. Wyznaczono rozkłady normalne dla każdego wierzchołka i ustalono podział P_1 na przyrosty małe i przyrosty duże. Nałożono wzorcowy rozkład normalny liczby sklerytów w przyroście całorocznym troci w wieku A.2+. Podział przesunął się w kierunku przyrostów małych. Wyznaczona wartość podziału P_2 (18 skleryt) rozdziela grupę A.1+ na trocie z tegorocznym oraz z zeszłorocznym przyrostem krawędziowym.

Empiryczny rozkład sklerytów w przyroście krawędziowym u troci o obrazie łuski A.2+ przyjął kształt jednowierzchołkowy. Wyznaczono rozkład normalny i porównano z wzorcowym rozkładem normalnym liczby sklerytów troci w wieku A.3+. Granica podziału P_2 przebiegająca między 12 a 13 sklerytem rozdziela ryby na z tegorocznym przyrostem i ryby z zeszłorocznym przyrostem krawędziowym. Obliczone pod krzywymi rozkładu normalnego pole jest prawdopodobieństwem błędu jakiego można się spodziewać przy oznaczaniu wieku troci o obrazie łuski A.2+ ze względu na wspólny obszar rozkładu przyrostów krawędziowych. Błąd ten wynosi dla troci z małym oraz z dużym przyrostem kolejno 5% i 12%.

Rozkład liczby sklerytów w przyroście krawędziowym łusek troci daje ten sam obraz jak rozkład krawędziowych przyrostów łuski przeliczanych na przyrost ciała , zatem analiza rozkładu wielkości przyrostów krawędziowych ma zastosowanie przy określaniu wieku stada tarłowego troci, a liczba sklerytów jest dobrą miarą do oceny wielkości tych przyrostów.

ADRES AUTORA:
mgr Paweł Buras
Instytut Rybactwa Śródlądowego,
Zakład Rybactwa Rzecznego w Żabieńcu ul. Główna 48
05-500 Piaseczno